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ABSTRACT

In senior-level undergraduate research courses in Computer Information Systems (CIS), students are required to read and assimilate a large volume of current research literature. One course objective is to demonstrate to the student that there are patterns or models or paradigms of research. A new approach in identifying research paradigms is proposed, one which is based on the use of the modeling tools of Systems Analysis and Design and a set of icons to graphically represent the research model components. One method for understanding the components and their relationships for a particular paradigm would be to apply a traditional functional decomposition method to the abstract model. Another method would be to apply the object-oriented approach. The necessary steps for using both approaches are explained, with five figures to depict the research model and icons. (Contains 10 references.) (Author/AEF)

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Paper

Taking the Mystery Out of Research in Computing Information Systems: A New Approach to Teaching Research Paradigm Architecture

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Abstract

In senior-level undergraduate research courses in Computer Information Systems, students are required to read and assimilate a large volume of current research literature. One course objective is to demonstrate to the student that there are patterns or models or paradigms of research. A new approach is proposed to aid the student in identifying the research paradigms. The new approach is based on the use of the modeling tools of Systems Analysis and Design and a set of icons to graphically represent the author's model of research.

Background

In the undergraduate course in Computer Information Systems (CIS) Research, the primary resources used are the professional journals and conference proceedings. Due to the expanding interpretation of the boundaries of the field, the amount of literature that is encompassed within the CIS curriculum can be overwhelming. The student may consider it all but impossible to keep abreast of developments in so many directions, and the likely course of action is that the student restricts themselves in the number of directions of interest. This recourse, however, can be self-defeating in that the richest discoveries have come from the cross-fertilization of interests, especially in the area of theory formulation. Therefore, a newer approach is needed to help the student better manage the process of gaining control over the flow of information about the research process.

Numerous journal articles and conference proceedings were analyzed, ranging from conceptual to applied to empirical research. Academic researchers were interviewed about their cognitive research models. From this work, it became apparent that there are basic similarities in the models the authors used in conducting and publishing their research. The intent of this paper is identify a number of the similarities and categorize the cognitive processes into discrete paradigms (as used in the Kuhnian sense) or models of research. The working hypothesis of the paper is that there are a finite number of concrete research paradigms that are used, often without the researcher realizing he or she is using them.

It is felt that the concrete models can be structured into architectures, thereby providing macro maps of the objects, actions, attributes and flows within the mystery land of Research. The architectures can be used by the student to group and classify

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existing paradigms. The benefits from such classification would be many, including identification of gaps, patterns and shifts in research models.

In summary, the newer approach to taking the mystery out of research is to identify the research paradigms currently used in the CIS literature, demonstrate how the paradigms can be used as basic elements, and how the elements can be framed into different architectures of the research process. The newer approach will provide a cognitive structure for research that could help the student focus their creativity on solutions, while the disciplinary courses provide the student with a structure of problems to be solved.

Research Paradigms and Their Representation

Research occurs at three broad levels. At the lower level of the pyramid are the disciplinary or exemplar paradigms, such as the paradigms of Economics, Marketing, Physics, Biology, etc. At the middle level of the pyramid are the paradigms that encompass a higher level of generalization, such as the broad paradigms of the social and physical sciences. At the highest level of the pyramid is a set of more universal research paradigms. The newer approach takes the top-down method of analyzing the overall system of research models and their architectures, and this requires an initial concentration of the top-level, encapsulating paradigms.

At the top level of the pyramid, the research process would include actions such as modeling, describing, theorizing, prescribing, proving, synthesizing, testing, solving, demonstrating, verifying, categorizing, and so forth. At the lower level the upper level actions would be operationalized into case studies, field studies, laboratory experiments, field experiments, and other paradigms of the CIS discipline.

At the top level, because of the lack of consensus and the imprecision of construct definition, it is more difficult to find acceptable representations or words to describe the research paradigms. At the lower level, because of the existence of consensus and the precision of construct definition, ideas can be readily translated into words with common meanings.

Representing Research Constructs with Icons

Icons give a generalized picture of the objects, the actions they take and their flows. Together, the icons can be grouped into larger frames or architectures that represent different models for conducting research in CIS.

Icons were selected as the Esperanto of the language of research models, since they are more independent of semantic representations than text. At the top level of the research pyramid the representation should be as context-free of domain specific language as possible so that the representation can be applied to many disciplinary areas.

Icons provide a richer, concrete representation of fuzzy constructs than text, and images, as pointed out by Aristotle, are the basic building blocks of thought. Think of how much easier it is to teach the statistical concepts of unions, intersection, and complements with Venn diagrams than with words.

Top-Level Research Paradigms in CIS

Based on the literature review and the interviews conducted for this study, a number of candidates appeared as top-level research paradigms. There are (but not limited to):

A. Formulation of new theory or hypothesis based on one's own research or generating theory or hypothesis through synthesis or generalization of another's research

B. Building models to solve existing problems and demonstrating how the models solve a class of problems

C. Applying existing models to new areas of application

D. Building frameworks or taxonomies to organize or inventory knowledge

E. Cross-fertilization or transfer of knowledge (theory or technique) from one discipline to another

F. Generalizing existing knowledge to higher levels of abstraction or to larger classes of problems; generalizing existing solutions to a totally different class of problems

G. Using inventories of knowledge as a base to demonstrate trends and make predictions

H. Identifying shifts away from a generally accepted research approach to a newer approach

I. Popularizing ideas and putting them in concrete form

J. Comparing practice versus theory, real versus ideal, or observed versus predicted

K. Delimiting gaps in knowledge, gaps between practice and theory, gaps between problems and solutions, gaps between the real and the ideal, or gaps between observed and predicted

L. Taking old concepts, filtering them and creating new concepts

Each of the paradigms above can be described by a series of interconnected icons representing the components of the model. The icons can be developed by the students themselves. For example, an icon of a library or book can be used to represent "theory," and an icon of a factory can be used to represent "practice" in the paradigm numbered "J" above. "Cross-fertilization" can be represented by an "X" in paradigm "E." An icon of a house being framed can be used to represent "building frameworks" in paradigm "D." A ladder can be used to represent paradigm "F." "Making predictions" in paradigm "G" could be represented by a crystal ball.

The components of the research model, as illustrated by the icons, can be subdivided into lower and lower levels. For example, the student can develop icons for lab experiments (a test tube or microscope, for example), questionnaires ("?"), and so forth.

Using Modeling Tools to Represent Research Models

One method for understanding the components and their relationships for a particular paradigm would be to apply a traditional functional decomposition method (such as with Data Flow Diagrams, for example) to the abstract model, much as the student has been taught in the Systems Analysis and Design course. In this approach, the processes would be successively decomposed into finer and finer grained modules. Another method for understanding the models would be to apply the object-oriented approach, in which the paradigm architectures consist of objects that are differentiated could be represented as in Figure 1.

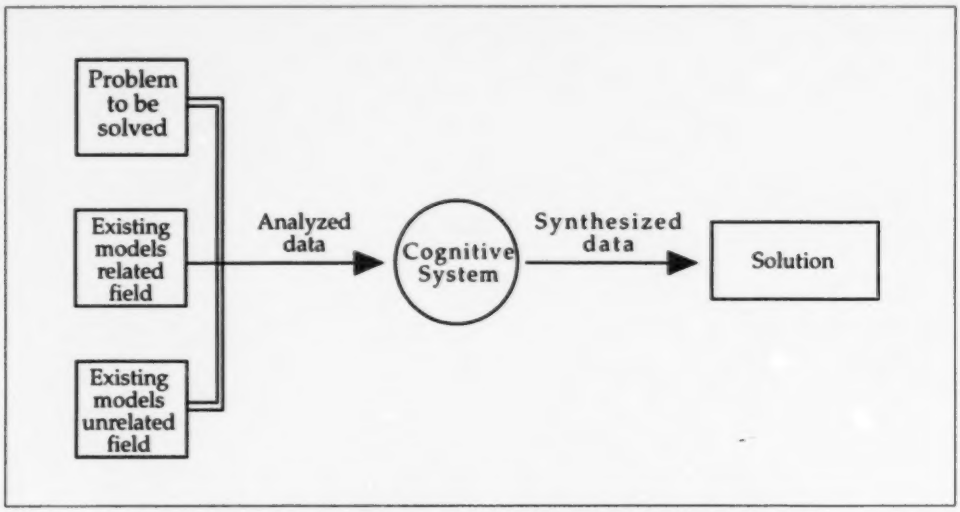

Figure 1. Top-level Data Flow Diagram of Research Model

In both the object and the functional approaches, the next step is to develop a lower level diagram, such as a data flow diagram as proposed by Tom DeMarco, Edward Yourdon, Chris Gane, and Trish Sarson. For example, this diagram (Figure 2) could appear as:

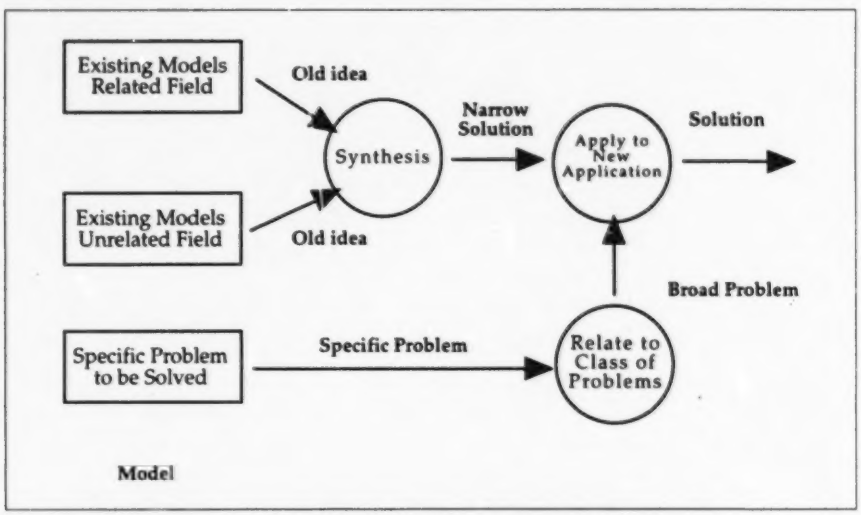

Figure 2. Lower-level Data Flow Diagram of Research Model

With a functional decomposition approach, the next step is to create a structure chart, such as developed by Edward Yourdon. However, the concept of modules and rigidly defined hierarchies of modules connotes a level of precision in definition that we are assuming doesn't exist for the student. Therefore, rather than applying an algorithmic decomposition approach, the student could then apply the object-oriented approach, with potential benefits to be repeated beyond the "design" stage.

In the object-oriented approach, our systematic approach to the analysis of research is decomposed into objects and messages. An object-oriented decomposition diagram or Booch Diagram of our problem domain could look as follows (see Figure 3):

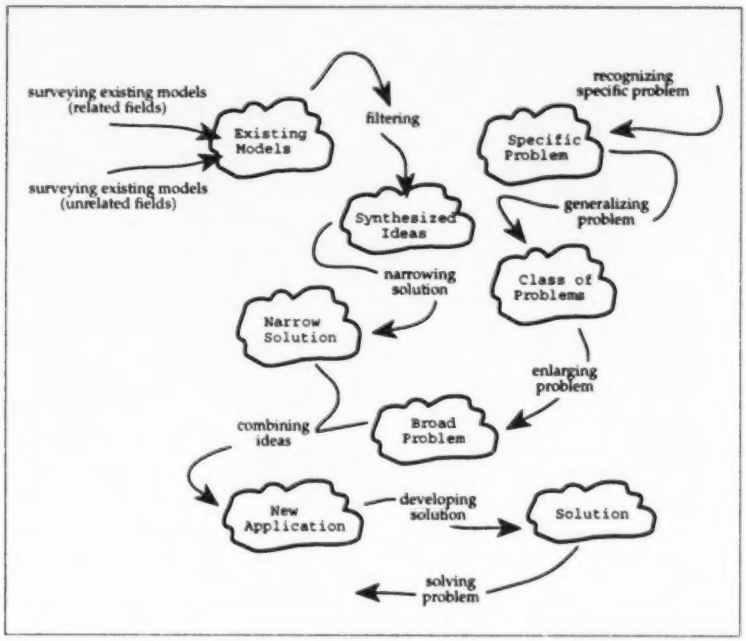

Figure 3. Object-oriented Decomposition of Research Model

At this point, icons can be applied to the objects and messages. The following icons are used for this research model are shown in Figure 4. The icons were taken from the CorelDraw Clip Art Library, rendered with *Poser*, resized with *Freehand*, and the layout was done with *QuarkXpress* on a Macintosh computer.

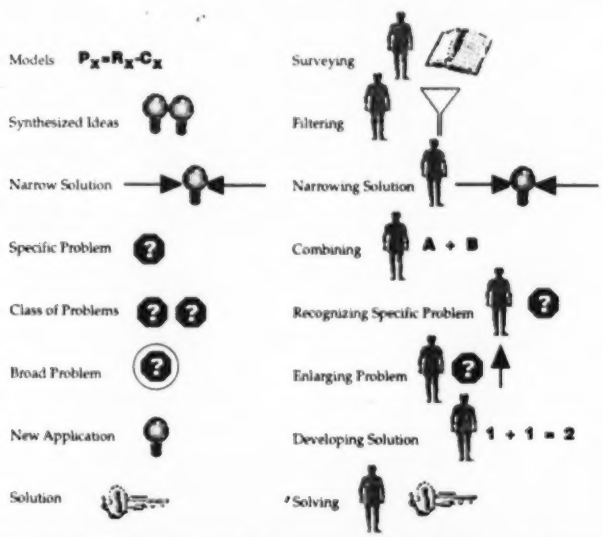

Figure 4. Icons Used in Representing Research Model

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Repeating Figure 3, the basic architecture of the research activity, using icons, would appear as Figure 5.

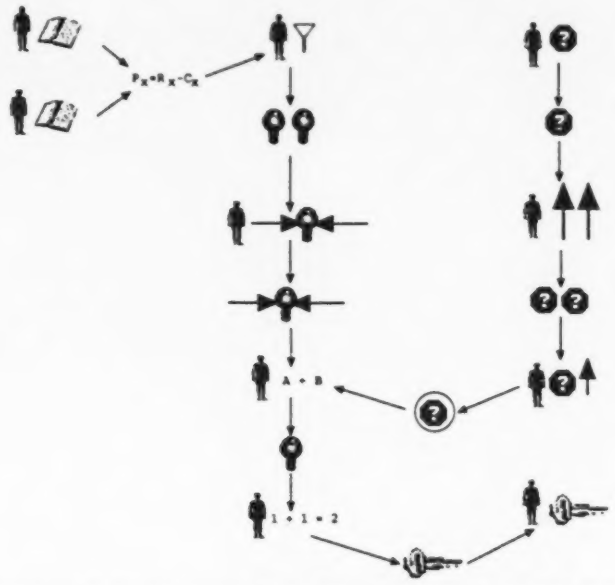

Figure 5. Iconic Representations of Research Model

Conclusions

The newer approach to defining research paradigms, combined with an object-oriented methodology for representing the architecture, provides a macro level series of slices through the research process. The slices or frames or packages, in turn, can be subdivided into finer-grained architectures.

It can be envisioned that the student will gather a large number of templates (such as in Figure 4) as he or she goes through the successive decomposition of the different levels of research for different journal or conference papers. It can be envisioned that the student can gather a number of icons and link them together to design a framework for the student's research project. The process of decomposition should expedite the student's appreciation of the similarities and differences of research models and thereby aid that student in managing the explosion of published research within the CIS field.

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